

SATELLITE COMMUNICATION SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation application of U.S. patent application Ser. No. 09/641,654, filed Aug. 18, 2000, titled "Satellite Payload Data Communications and Processing Techniques."

BACKGROUND OF THE INVENTION

[0002] This invention relates to satellite communication systems, and more specifically relates to such systems in which satellite data is processed by an earth processing center.

[0003] Satellite communications are taking on increased importance as evidenced by the following patents issued in the name of one of the inventors of the present invention: U.S. Pat. No. 5,867,530, entitled "Method and Apparatus for Accommodating Signal Blockage in Satellite Mobile Radio Systems," issued in the name of Keith R. Jenkin, on Feb. 2, 1999 and U.S. Pat. No. 5,940,444, entitled "DARS PSF With No Data Rate Increase," issued in the name of Keith R. Jenkin and Stephen J. Toner on Aug. 17, 1999.

[0004] Prior satellite communication systems requiring earth processing centers including, for example, weather satellite systems. In such a system, one or more traditional ground stations are used. The weather satellite collects data continuously and saves it onboard, and then "dumps" that data as it over flies a traditional ground station. Polar locations are chosen as sites for traditional polar orbiting missions since the poles are overflowed on every orbit, thus minimizing the number of traditional ground stations needed. (If the stations were located elsewhere, say near the equator, a prohibitively large number of these expensive facilities and sustaining staff ringing the globe would be needed to avoid blind orbits.)

Significant Data Timeliness Compromise

[0005] Mission data is continuously collected and stored onboard until a traditional ground station is encountered. This results in data already being delayed by up to as much as approximately 100 minutes before it even reaches the ground, which for weather data is highly undesirable.

Traditional Ground Station Complexity and Cost

[0006] Since there are very few downlink opportunities, and each of them is usually critical to prevent blind orbits, the stations must have extremely reliable communications with the satellite to avoid unacceptable performance. Usually a bi-directional system is used (both downlink and uplink) to first establish a valid link, then command the satellite to begin the downlink process. Data integrity can be checked in near real time on the ground, and handshaking schemes can instigate the retransmission of data packets in more sophisticated systems. A full time (24-7) crew is essential at traditional ground stations for rapid repairs if needed, and also man-in-the-loop scheduling conditions automated systems can't handle (i.e. preemption situations). In remote regions the continuous staffing required over many years becomes a major consideration in program life cycle cost. In a case like McMurdo (Antarctica) the environment is incredibly adverse, and logistics become a major

concern. While adding the example McMurdo is attractive since the nominal maximum onboard storage time is reduced to half an orbit instead of one orbit, the programmatic impact is substantial.

Minimum Pass Limitation Of Prior Systems

[0007] Since a downlink to a traditional ground station is a complex operation, a practical limit on the geometrically available contact time is usually imposed. The ground station antenna (which might service several other satellites too) needs to be slewed, signal acquisition accomplished, and reliable communications need to be established. Therefore, otherwise viable contacts at a traditional ground station are discarded if the contact opportunities are somewhat short, such as five minutes (of a nominal 12 minute pass time). The preferred embodiment of the present invention does not require a minimum pass limitation, since it is a dedicated, mission-captive capability. Furthermore, even "scraps" of mission data (small periods) are useful in the preferred embodiment architecture, since it will be shown that all received valid data, no matter how small or redundant, become amalgamated or used as checks upon arrival at the processing center.

Ground Communication Drawbacks of Prior Systems

[0008] Since the traditional ground stations are generally located in remote, sparsely populated areas, taking advantage of commercially financed, installed, and maintained fiber optic networks is unlikely since there is no financial motivation for servicing such geographic (polar) areas. This means communication from traditional ground stations to the processing center (probably in the U.S.) is expensive for the data rates (bandwidth) needed by future weather satellites. Either dedicated, sole-user fiber is needed, or perhaps a complex, risky, and expensive "hop" from the station to a communications satellite and back to the U.S. is needed. Or, a slow existing link might be used, but because of limited bandwidth, data will again be delayed awaiting its turn in a rate buffer queue for ground communication.

Frailty of Prior Systems

[0009] Since there are, practically speaking, several single point failure opportunities in a traditional ground station system, each point must have incredibly high (i.e. expensive) reliability and sufficient availability. For instance, if a key station is down for a prolonged period, say due to earthquake damage, or immediately irreparable equipment failure, or staffing problems and so on, critical data will be lost or arrive so late it's essentially useless.

Spacecraft Complexity/Risk of Prior Systems

[0010] Since passage over a traditional ground station is on the order of 10 minutes, and the stored data is from a nominal 100 minute orbit, high downlink data rates (a minimum of 10x payload data rate) need a spacecraft pointable, high gain antenna to keep spacecraft electrical power and transmitter needs reasonable. This means either moving mechanical parts (an articulated gimbal system), or possibly a phased array antenna (complex). Since the spacecraft antenna is highly directional (continuously dynamically pointed at the ground station) and since transmit power is limited, only one ground station at a time can be downlinked. Furthermore, if subsequent contact opportunities arise, a gimballed spacecraft antenna needs precious time to slew and repoint.